Oklahoma Disaster Management very crude first rough draft

Background and Introduction

Since people have inhabited the Southern Great Plains, the region has been known for its frequent tornadoes. Due to the frequency at which these tornadoes occur, the entire region from the Texas panhandle to northern Kansas has been named “Tornado Alley.” Lying in the very heart of this region is the state of Oklahoma, the most tornado-ridden area in the United States. From a statistical standpoint, Oklahoma suffers an average of 19.7 tornadoes per 10,000 square miles based on data from the years 1880-1989. This ratio translates into roughly 54 tornadoes a year. Despite that yearly average, storm cells in the region have been known to produce an excess of 50 tornadoes in a single day. A perfect example of this extreme is May 3, 1999, when a total of 66 tornadoes touched down across Oklahoma and Kansas, killing 46 people, injuring another 800 and ultimately resulting with over 1.5 billion dollars in damages. Recognizing the extent of this damage, the citizens of Oklahoma are greatly concerned with improved storm prediction, especially in the frequency of storm warnings.

Through in depth research, forecasters have associated the formation of severe storm outbreaks to deep convection in the atmosphere. Convection, or the cyclical process of rising warm, moist air through cooler, dry air, and the falling of cool air through warm air masses, occurs frequently in the region surrounding Oklahoma due to the mixing of dry air from the Rocky Mountains and moist air from the Gulf of Mexico. Under these prime conditions, deep convective cells often form and lead to severe storms. In order for storms to develop from convection, several factors must exist simultaneously in the atmosphere: instability, the presence of moisture, and a lifting mechanism to initiate the convection process. The lifting mechanism causes convection to begin by forcing parcels of air above the level of free convection, or the atmospheric level where the parcel of air does not have to expend any energy to rise. Once the parcels of air reach this level, they continue to rise until reaching equilibrium, or the level at which the ambient temperature is equal to that of the rising parcel. However, due to the momentum already possessed by the parcel, it will over shoot the equilibrium level and then spread out, forming the typical anvil shape of a storm cloud. Once the parcel rises above the equilibrium level, the parcel will then descend and begin an oscillating pattern that allows for moisture to condense, resulting in precipitation down through the upward drafts.

Since scientists do not currently have a concrete understanding of the process of convection, several efforts have been undertaken to gather more data to aid meteorologists in this understanding. The International H2O Project (IHOP) and the Oklahoma Mesonet are two such endeavors that have gathered vast amounts of data that are now readily available for use and interpretation. IHOP was an international project that was composed of over 200 scientists representing the United States, France, Germany, and Canada. A portion of the project utilized NASA’s Lidar Atmospheric Sensing Experiment (LASE), which is a NASA coordinated program to produce an autonomous system for measuring water vapor levels from airborne and spaceborne platforms using Lidar technology. Lidar technology, specifically the Differential Absorption Lidar (DIAL) instrument, works by emitting two pulses of light at different wavelengths and then measuring the difference between the intensities of the return signals. Via computer processing, the concentration of the targeted water vapor molecule is determined and reported for use in data interpretation. In stark difference to the air-bourn sensors, such as the DIAL instrument, the Oklahoma Mesonet observes current weather from 110 automated monitoring stations across Oklahoma. Mesonet is derived from the terms mesoscale, which refers to weather events ranging in size from a few kilometers to several hundred kilometers and lasting from several minutes to several hours in duration, and network. As such, the objective of the Oklahoma Mesonet is to observe and measure the environment during mesoscale events. The automated stations observe the atmosphere in five-minute intervals and then transmit the observations to a central facility where the data is compiled and provided to customers. Through the use of data, such as that gathered by IHOP and the Oklahoma Mesonet, the process of convection initiation can be better understood and improved predictions can be produced.

Based on the general need for improving the knowledge of convection, the Oklahoma Disaster Management project was formed by the DEVELOP program in the summer of 2003. The project focuses on expanding the general understanding of convection so as to improve the accuracy of storm watch boxes and limit storm warnings to the public to only those that are truly necessary. Through the use of three-dimensional visualizations, this project demonstrates convective instability parameters in a way that is easily understood. Thus, through the use of combined NASA and non-NASA datasets, the Oklahoma Disaster Management project can show several different parameters and how these parameters interact with one another. This project will also benefit policy-makers by aiding them with severe weather decision support.

Methods

The three-dimensional visualizations implement data collected during LASE, from the Oklahoma Mesonet, and from the Automated Surface Observing System (ASOS), which is a network of nation-wide weather observing stations updated every hour. The data from these sources are measured data, which means that it is considered valid by researchers. From LASE, water vapor mixing ratio and equivalent potential temperature vertical profiles were incorporated into the visuals. Water vapor mixing ratio is a measure of the amount of water vapor in the air, specifically it is measured in grams of water vapor per kilogram of dry air, and equivalent potential temperature is a measure of atmospheric temperature if a particular parcel of air is taken adiabatically to 1,000 millibars of pressure and all the water vapor is removed. The point of equivalent potential temperature is that it is impossible to compare the temperature of different parcels of air due to the variation in temperature due to altitude and the amount of water vapor in the air. Lastly from the IHOP data, convective inhibition (CIN) and convective available potential energy (CAPE) were calculated and used. Both are convective instability parameters measured in Joules per kilogram and represent the amount of energy that must be expended to reach the level of free convection and the potential energy possessed by a parcel respectively. The higher the CAPE is for a particular parcel of air, the greater the chance for deep convection.

Originally, the computer program, *Corel Bryce 5*, was used to create a visual for data from June 9th, 2002, showing water vapor mixing ratio profiles from the LASE instrument, and total precipital water vapor taken from the MODIS instrument on board the Terra satellite. This visual was taken to the 2004 annual American Meteorologist Society's meeting and displayed for the scientific community. The actual process used to create the visual was relatively simple, images of the data were simply input into the program, and then the camera angles were manipulated to create a fly-through. After this original visual, alternate sources for ground-based data were used to focus more specifically on the area under examination.

Using the three-dimensional computer imaging program *Maya 4.5 Complete*, additional visuals for May 24, 2002 were created that incorporate Oklahoma Mesonet data and vertical profiles from the LASE instrument. Using Mesonet data gathered at different times, the horizontal images faded in between times, originally in a video created in *Macromedia Flash MX*, but ultimately through the use of *Maya*'s tools. However, the Mesonet data was later removed and replaced with data from the Automated Surface Observing System (ASOS) spanning between 1500 UTC and 2300 UTC because portions of Texas were included within the visual. The data displayed in the May 24th visuals included water vapor mixing ratio, equivalent potential temperature, convective inhibition (CIN), and convective available potential energy (CAPE). With CAPE and CIN shown in addition to water vapor mixing ratio and equivalent potential temperature so as to further the understanding of the relationship between these parameters and the occurrence of convection. Once ASOS images are generated in *Gempak* for June 9th, 2002, a similar visual will be constructed in the likeness of those created for May 24th. After these three-dimensional visualizations are completed, visuals utilizing data from the Rapid Update Cycle (RUC) model will be created to allow for comparison between data from the measured datasets to that gathered using the RUC model.

Conclusions

Due to the comparisons between the two visualizations for May 24, 2002, it can be seen that greater values of CAPE occur at locations where there is greater water vapor mixing ratio and equivalent potential temperature at lower altitudes. As the visuals play, it becomes apparent where this occurs. On the left side of the vertical profile the vales of CIN are much greater than those of CAPE, in fact the CAPE values are hardly visible in the images. One can see that the values of both water vapor mixing ratio and equivalent potential temperature are both proportionally lower on the left, where CIN overrides the CAPE, than on the right were the opposite occurs. As the water vapor mixing ratio and equivalent potential temperature are greater, the point values of CAPE increase dramatically. Additionally the … of the data is shown in that the ASOS ground images match up exactly to the vertical profiles at ground level.

Upon the completion of all visuals, the team will undertake a specific study comparing the ASOS and IHOP data with that gained from the RUC model. The objective of this study is to observe the similarities and differences in the different data sources. The team expects that there will be differences in areas where convection occurred as the RUC model is used to predict weather, thus it seeks a more general view than that of the point source data which focuses on individual regions. As such, the team will show meteorologists that through the use of more specific data sources, predictive capabilities may be increased. Additionally the results of the project will point out the benefits of using multiple different parameters to increase the abilities of current predictive models.